Photon Quality Measure

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Outline

Aim: Find a measure of photon quality using combination of EMC variables
(The Study Formerly Known as ’Splitoffs’)

• MC sample, choice of discriminant
• Description of NN inputs
• Description of NN outputs
• Construction of photon quality measure
• It works!
• Implementation
• Future possibilities
Method

- Working in analysis-21
- 500000 generic $B\bar{B}$ MC events used to train discriminator
- At Beta level, iterate over CalorNeutralList, if entry truthmatched to photon, call it 'signal', otherwise it’s 'background'.
- Tested Fisher discriminant and neural net, NN by far the superior discriminator
- Use root function TMultiLayerPerceptron
  - default constructor (stochastic minimisation)
  - 1 hidden layer with 5 neurons
  - 50 training cycles

NN inputs

- Use 6 cluster-shape variables as inputs to the NN, plus distance of closest approach of nearest track ('nearest' measured by doca)
- If \( \text{doca} > 50 \text{cm} \), set \( \text{doca} = 50 \text{cm} \)
- Ecal a very useful discriminator, but don’t want to use it as direct input due to energy bias, \( \therefore \) train NN separately in ecal bins.
  - 50 MeV bins up to 0.5 GeV
  - 100 MeV bins 0.5-1 GeV
  - 200 MeV bins 1-2 GeV
  - 500 MeV bins 2-3.5 GeV
  - 3.5 GeV+
- Plots of input variables from generic $B\bar{B}$ MC 

signal (photons) and background (non-photons) 
s1s9, s9s25

lateral moment, second moment TP

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absZernike20, absZernike42

doca, ecal
NN outputs

Neural Net outputs and efficiency (x) vs purity (y) plots for some example ecal bins.

*signal (photons) and background (non-photons)*

ecal 0.05-0.1 GeV

![NN output](image)

*e cal 0.25-0.3 GeV

![NN output](image)
ecal 0.5-0.6 GeV

NN output

Efficiency:purity

ecal 1.0-1.2 GeV

NN output

Efficiency:purity

ecal 1.8-2.0 GeV

NN output

Efficiency:purity

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- As the NN varies from ecal bin to bin, raw NN output not suitable for quality measure.
- Instead, use proportion of signal remaining if you were to cut at that value of NN output.
- Signal shape doesn’t change much in different MC samples, but backgrounds do.

For example ecal bin 100-150 MeV.

Signal NN output, background NN output, photon quality output function.
Plot of photon quality measure for all ecal energies (binned in NN output) 

truthmatched photons, non-photons.
it’s a Good Thing

Comparison of performance of LAT cut alone compared to cut on NN-based photon quality measure, over all ecal bins.

NN measure, LAT cut alone, LAT cut with LAT!=0

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</table>
For low (<200MeV) ecal energies quality measure is better than LAT alone:

At high ecal energies (ecal>2GeV), measure only slightly better than LAT alone:

Also, measure takes account of LAT=0 problem.
Implementation

(working in 16.0.1a)

- Some debate as to appropriate home for this
- EmcPid package - EmcPid/EmcNNPhotonQuality
- Based on EmcPid/EmcPhotonIdentifier.hh
- Nearly finished coding
- What to use for likelihood/consistency inputs?
- Need to validate/test on various MC, data
- How will people access it in your average Beta job?
Conclusion

- Study very nearly finished

- Measure is useful - should be used

- We may want NN without doca also, usage depends on analysis

- Possibly could be basis of photon list